动 物 学 研 究 2006, Aug. 27(4): 357 – 362 CN 53 – 1040/Q ISSN 0254 – 5853
Zoological Research

# Effects of Group Size on Vigilance Behavior of Wintering Common Cranes *Grus grus*

YANG Yang[1], CHEN Wen-hua[1], JIANG Wang-gao[1], YANG Shi-jian[2,*], PENG Gui-hong[3], HUANG Ting-fa[3]

(1. *Yunnan University, Kunming* 650091, *China*; 2. *Yunnan Normal University, Kunming* 650091, *China*; 3. *Administration Bureau of Plateau Wetland Nature Reserve of Lashihai, Lijiang* 674107, *China*)

**Abstract:** From January to March 2005, the effects of group size on the vigilance behavior of wintering Common Cranes *Grus grus* were studied at Lashihai Lake, Yunnan Province, China. We used scan sampling to record the group sizes and the number of vigilant individuals in each group, and focal sampling to record the frequency and duration of individual vigilance behavior. Both the vigilance efforts of groups and individuals significantly decreased as group size increased, but when the group size exceeded 30 individuals, the decrease of group vigilance became not significant ($P > 0.05$), and the vigilance duration of adult cranes increased ($P < 0.01$). The vigilance frequency of adults increased ($P < 0.05$) when the size exceeded 50 individuals. Presumably, the maximal group size allowing the lowest vigilance for juvenile cranes was larger than that for adults, and the flocks composed of 20 to 30 individuals represented the optimal group size of wintering Common Cranes by considering only the vigilance behavior. Further research should focus on the synthesized effects of various factors.

**Key words:** *Grus grus*; Group size; Vigilance effort; Frequency; Duration

# 群体规模对越冬灰鹤警戒行为的影响

杨 洋[1], 陈文华[1], 江望高[1], 杨士剑[2,*], 彭贵鸿[3], 黄庭发[3]

(1. 云南大学, 云南 昆明 650091; 2. 云南师范大学, 云南 昆明 650091;
3. 云南丽江拉市海高原湿地省级自然保护区 管理局, 云南 丽江 674107)

**摘要:** 2005 年 1—3 月, 在云南丽江拉市海就群体规模对越冬灰鹤(*Grus grus*)警戒行为的影响进行了研究。用扫描取样记录群体的规模和警戒个体的数量、用焦点取样记录群体中个体警戒行为的频次和持续时间, 结果显示: 灰鹤群体和个体的警戒力均随群体规模增加而降低, 但集群个体数超过 30 只后, 群体警戒力便不会再下降($P > 0.05$)、成体的警戒持续时间也会增加($P < 0.01$); 当群体规模超过 50 只后, 成体的警戒频次也会上升($P < 0.05$)。推测亚成体维持低警戒的群体规模上限值要高于成体, 单从警戒行为分析, 20—30 只个体的集群可能代表越冬灰鹤的最适群体大小。

**关键词:** 灰鹤; 群体规模; 警戒力; 频次; 持续时间
**中图分类号:** Q959.726; Q958.12 **文献标识码:** A **文章编号:** 0254 – 5853(2006)04 – 0357 – 06

There have been extensive studies about the aggregating behavior of birds up to the present. The time devoted to vigilance by birds in flocks decreases as group size increases, so that individuals can spend more time feeding without reducing their level of safety (Fleischer, 1983; Martella et al, 1995; Petit & Bilestein, 1987; South & Jones, 2000). In addition, flocking can also assist in thermoregulating of the homeotherm

* Received date: 2006 – 01 – 12; Accepted date: 2006 – 03 – 28
Foundation item: This work was supported by Provincial Basic Research Program of Yunnan (03C0031M)
* Corresponding author(通讯作者), E-mail: bioearth@sina.com
收稿日期: 2006 – 01 – 12; 接受日期: 2006 – 03 – 28
基金项目: 云南省自然科学基金资助项目(03C0031M)

(Jiang, 2004). But aggregation into flocks increases intraspecific competition for food resources (Sun, 2001). Pulliam (1973) indicated that while the number of individuals in avian groups exceeded a definite number, further increases of group size would not accelerate the decrease of vigilance any further (Shang, 1998).

The Common Crane *Grus grus* is one of the National Second-grade Protected animal species in China, distributed throughout the wetlands of the Northern Hemisphere. In terms of ethology, there have been many studies about its time budget (Alonso & Alonso, 1990; Alonso & Alonso, 1993; Avilés, 2003), spatial distribution (Alonso et al, 1994; Alonso et al, 2004) and the population dynamics (Bautista et al, 1992) at Laguna de Gallocanta and Serena in Spain. However, the quantitative relationship between the group size and vigilance of Common Cranes remains poorly known.

In order to study the effects of group size on the vigilance of Common Cranes in the wintering season, the research was performed at Lashihai Lake, Yunnan, China, from January to March 2005.

## 1 Materials and Methods

### 1.1 Study site

Lashihai Lake (100°07′ – 100°09′ E, 26°52′ – 26°54′N) is a plateau wetland at an altitude of 2 400 m in northwestern Yunnan, China. The annual average temperature is about 11 ℃. It is an important wintering site for migratory waterbirds in the Trans-Himalayas of Yunnan (Quan et al, 2002). The lake covers about 10 $km^2$, surrounded by alluvial and agricultural soil. The grasslands were adjacent to water, with open farmlands outwards. About 3 000 Naxi people live in four villages nearby the water level, who utilize the ground around the lake mainly for cultivation and livestock grazing.

### 1.2 Group types

Common Cranes wintering at the study site roosted in ruderal fallow farmlands at night, foraged in the farmlands and sporadically flew to the lakefront for maintenance activities, such as preening and washing during the daytime.

The social structure of Common Cranes wintering at Lashihai Lake included two types: groups and solitary individuals far away from groups. Solitary cranes observed only twice were omitted in the census and behavior sampling.

Group size of wintering Commons Cranes varied from one isolated family (a mated pair with their accompanying one or two juveniles) to large groups mainly composed of adults without offspring and a variable number of families (Alonso & Alonso, 1993). Besides this, some mated adults without offspring feeding out of groups were observed in our study. So we defined two elementary group types: family (mated adult cranes with 0 – 2 juveniles) and flocks (groups of 5 or more cranes).

Furthermore, Avilés (2003) classified flocks of Common Cranes as small (10 birds) and large (> 10 birds). Based on the above classification, the large flocks clarified by Avilés (2003) were approximately defined as five flock types according to numerical variety (Fig. 1). A group (family or flock) further than 200 m away from the other was regarded as being isolated, and the distance was evaluated by eye according to crane individual total length.

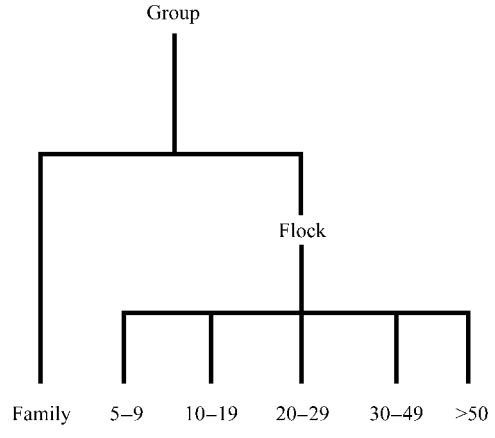


Fig. 1 Group types

"5 – 9" means flocks composed of 5 – 9 cranes; "> 50" means flocks of more than 50 cranes; the same meanings that representing a title of one type of group respectively were for the others.

### 1.3 The definition of vigilance behavior

Vigilance: Head up to scan the surroundings, standing or walking with visible and frequent head turning, which is the distinction between vigilance and resting or locomotion behavior.

### 1.4 Data collection and analysis

Five fixed observation areas around the lake were selected to count the number of Common Cranes, and five people conducted isochronous and direct counts with 10× binoculars in each area from 8:00 to 9:00 in the morning of every day. The largest number counted during a cycle of five days was considered as the population number of the periods. Flock samples were selected randomly to determine the proportion of juveniles in flocks at the time of the census.

The total number of individuals and number of vigilant individuals in groups was recorded by scan sam-

pling at five minutes intervals. The vigilance frequency in five minutes and the duration of vigilance bouts of individuals were recorded by focal sampling. When conducting focal sampling, for each group we recorded the behavior of 1 – 10 adults and 1 – 5 juveniles. The recorded numbers of each were approximately proportional to the numbers in the group, and focal individuals in one group were selected at more or less regular distance intervals along the group's longest diameter to avoid biases due to individual position in the group (Inglis & Lazarus, 1981; but see in Alonso & Alonso, 1993). From 8:00 am to 19:00 pm, behavior sampling on Common Cranes feeding in farmlands without interference was conducted with 16 – 50 × monocular telescope, unless most cranes showed long-playing vigilance caused by the interference from the presence of humans and livestock.

For analysis, t-tests was used to compare the vigilance of adults with that of juveniles in the same types of group. One-way ANOVAs were used to test the difference in vigilance among six group types, and the multiple comparisons were conducted by Newman-Keuls tests (one method of LSR) to figure out the $q$-value for evaluating the difference in vigilance between the two group types.

## 2 Results

From January to March 2005, 816 scanned groups, 16 032 scanned individuals, 219 focal adults and 115 focal juveniles were observed. Three thousand one hundred and twenty five completed vigilance behavioral events were recorded, including 2 093 of adults and 1 032 of juveniles. In terms of census, we had completed the counts of 18 cycles in 90 days in total, 209 groups (56 of families, 153 of flocks) and 2 827 individuals (167 in families, 2 660 in flocks) were counted. Besides this, 89 flocks were selected for determining the age structure of flocks. However, scan sampling was not conducted on families, neither was focal sampling on juveniles in flocks of more than 50 cranes.

### 2.1 Population number, individuals in group and proportion of juvenile in flocks

The population number of Common Cranes wintering at Lashihai Lake was 91.50 ± 37.495 (Mean ± $SD$, $n$ = 6) in January, 49.67 ± 19.325 ($n$ = 6) in February and 41.00 ± 32.280 ($n$ = 6) in March. All cranes left for spring migration after 31 March. From January to March, the mean number of individuals in one group varied from 2 to 87 (2 to 4 in families, 5 to 87 in flocks), and was 16.06 ± 15.684 in January, 11.31 ± 8.858 in February and 12.24 ± 9.284 in March. The proportion of juveniles in flocks was approximately 22.12%.

### 2.2 Vigilance effort of individuals

Vigilance effort of individuals was evaluated using two parameters: vigilance frequency (times) in five minutes and duration (seconds) of vigilance bouts, (hereafter referred to as "frequency" and "duration"). Individual vigilance frequency and duration, and the $t$-value for testing the age-related difference are showed in Tab. 1.

One-way ANOVAs show that among different group types, there are significant differences in the vigilance effort of individuals ($P < 0.001$), the correlative parameters are showed in Tab. 2. The $q$-value for multiple comparisons and the variety of the vigilance effort of individuals are showed in Tab. 3 and Fig. 2 respectively.

**Tab. 1　Individual vigilance frequency, duration (Mean ± $SD$) and age-related difference ($t$-test)**

| | Frequency | | | | | |
|---|---|---|---|---|---|---|
| | Family | 5 – 9 | 10 – 19 | 20 – 29 | 30 – 49 | > 50 |
| Adult | 13.11 ± 5.057 | 9.75 ± 5.067 | 7.81 ± 4.410 | 6.68 ± 3.747 | 7.88 ± 6.677 | 13.60 ± 5.941 |
| Juvenile | 11.87 ± 5.043 | 7.00 ± 3.984 | 8.75 ± 4.882 | 5.09 ± 3.145 | 5.50 ± 6.568 | |
| $t$-value | 1.445 | 3.475 | 1.024 | 1.462 | 0.864 | |
| $P$ | 0.232 | 0.070 | 0.314 | 0.236 | 0.357 | |
| $df$ | 99 | 39 | 101 | 31 | 49 | |
| | Duration | | | | | |
| | Family | 5 – 9 | 10 – 19 | 20 – 29 | 30 – 49 | > 50 |
| Adult | 12.97 ± 16.689 | 10.01 ± 9.505 | 5.18 ± 3.279 | 6.61 ± 4.795 | 14.08 ± 46.952 | 8.23 ± 3.132 |
| Juvenile | 7.90 ± 6.483 | 14.83 ± 10.721 | 5.63 ± 3.621 | 6.65 ± 3.946 | 5.16 ± 2.810 | |
| $t$-value | 6.281 | 4.311 | 1.895 | 0.055 | 3.451 | |
| $P$ | < 0.01 | < 0.01 | 0.059 | 0.956 | < 0.01 | |
| $df$ | 1 274 | 351 | 840 | 201 | 381 | |

**Tab. 2 One-way ANOVA about the vigilance effort of individuals**

| | Adult | | Juvenile | |
|---|---|---|---|---|
| | Frequency | Duration | Frequency | Duration |
| *F* | 10.24 | 10.78 | 7.10 | 52.39 |
| *df* | 5,213 | 5,2 087 | 4,110 | 4,1 027 |
| *P* | < 0.001 | < 0.001 | < 0.001 | < 0.001 |

**Tab. 3 Multiple comparisons of individual vigilance frequency and duration among group types**

| | Family | 5 – 9 | 10 – 19 | 20 – 29 | 30 – 49 | > 50 | |
|---|---|---|---|---|---|---|---|
| Family | | 3.836 0** | 8.129 8** | 7.106 7** | 7.225 8** | 0.287 3 | Frequency |
| | | 2.585 4 | 8.813 3** | 4.584 5** | 1.098 3 | 2.426 9 | Duration |
| 5 – 9 | *4.923 0*** | | 2.218 4 | 2.850 6 | 2.008 6 | 2.147 7 | Frequency |
| | *15.522 8*** | | 3.924 0* | 2.081 7 | 3.092 2 | 0.831 6 | Duration |
| 10 – 19 | *4.074 1*** | *1.775 1* | | 1.248 8 | 0.102 9 | 3.417 7 | Frequency |
| | *7.368 8*** | *19.953 1*** | | 0.984 3 | 8.137 8** | 1.523 0 | Duration |
| 20 – 29 | *5.833 2*** | *1.448 9* | *3.156 4* | | 1.257 4 | 3.829 3* | Frequency |
| | *2.031 3* | *11.618 5*** | *1.629 7* | | 4.879 7** | 0.712 7 | Duration |
| 30 – 49 | *4.821 3*** | *1.027 5* | *2.464 4* | *0.258 6* | | 3.317 6 | Frequency |
| | *4.032 0** | *12.621 5*** | *0.685 1* | *1.708 2* | | 2.840 1 | Duration |

Numbers in Table denote the q-value for multiple comparisons of vigilance effort of individuals among group types, the italic ones in the foot left are for juveniles, while the others in the top right for adults.
*$P < 0.05$, **$P < 0.01$.

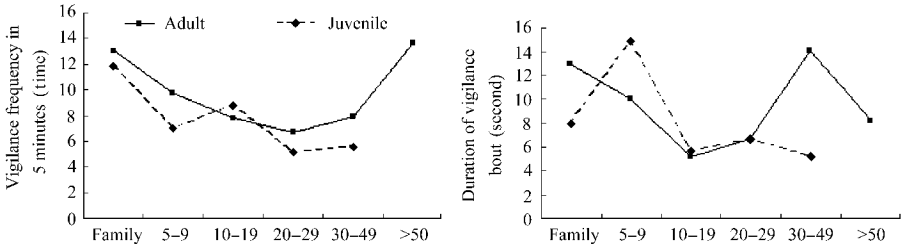


Fig. 2 Vigilance frequency and duration of individuals in each type of group

## 2.3 Vigilance effort of groups

The vigilance effort of groups was evaluated by the percentage of vigilant individuals. Fig. 3 shows the vigilance percentage of each flock type. One-way ANOVAs show that among different flock types, there was a significant difference in the vigilance effort of groups ($F = 18.01$, $P < 0.001$, $df = 4, 811$). Tab. 4 shows the $q$-value for multiple comparisons.

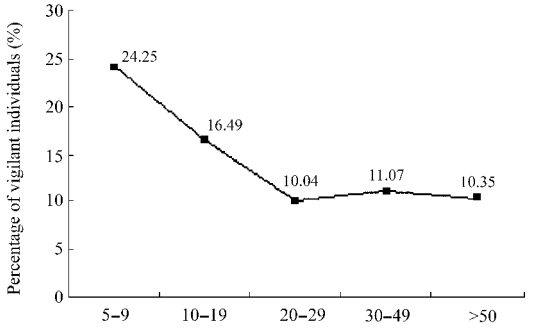


Fig. 3 Vigilance percentage in each flock type

**Tab. 4 Multiple comparisons of vigilance percentage among flock types**

| | 10 – 19 | 20 – 29 | 30 – 49 | > 50 |
|---|---|---|---|---|
| 5 – 9 | 6.044 8** | 10.235 2** | 7.766 9** | 8.368 9** |
| 10 – 19 | | 7.507 5** | 4.168 9** | 4.901 6** |
| 20 – 29 | | | 0.735 6 | 0.232 5 |
| 30 – 49 | | | | 0.429 0 |

Numbers in Table denote the $q$-value for multiple comparisons of vigilance effort of groups among flock types.
**$P < 0.01$.

# 3 Discussion

Common Cranes are territorial in the breeding season, and usually gregarious during migration and wintering (Alonso et al, 2004). The optimal foraging strategy and the response to predation risk is believed to have led to large flocks of Common Cranes in the non-breeding season (Alonso & Alonso, 1990). Predation risk is taken to mean any interference that can interrupt the feeding or other activities of animals. No natural predator of the Common Crane was observed during the

study. However, the distribution of waterbirds at Lashihai Lake is mainly affected by habitat disturbances (Quan et al, 2002) and therefore the predation risk to the Common Cranes wintering there is mainly from local farmers, tourists and livestock. Social feeding could reduce the predation risk, so that as group size increased, the time devoted to vigilance by individuals decreased, but the intraspecific competition for food resources (Sun, 2001) increased. The costs of intraspecific interference offsets the benefits of flocking, individuals having to spend more time being alert to each other to avoid interference. Therefore further increases of group size would not accelerate the decrease of vigilance any further.

The vigilance of adult cranes decreased as group size increased, but multiple comparisons show that the vigilance duration of adults increased when group size exceeded 30 individuals (Tab. 3, Fig. 2). This suggests that flocks of about 30 individuals presumably represented the maximal group size allowing the lowest vigilance effort for adult cranes. Since focal sampling wasn't conducted on the juveniles in flocks of more than 50 individuals, the maximal group size for juveniles is still unknown. But for juveniles, as group size increased, both the vigilance frequency and duration varied without significant increase (Tab. 3, Fig. 2). Accordingly, the maximal group size allowing the lowest vigilance effort for juvenile cranes presumably was larger than that for adults. Differences in vigilance effort between adults and juveniles only existed in the duration of vigilance behaviour; the vigilance of juvenile cranes was lower in family and "30 – 49" groups and higher only in "5 – 9" groups than that of adults. Age-related differences were not significant in other group types (Tab. 1). This suggests that juvenile Common Cranes were likely to be more adaptive to larger flocking, leastways in the area of Lashihai Lake.

Alonso & Alonso (1990) indicated that the optimal group size of juvenile cranes should be families or small flocks, because juveniles needed special environments with less intraspecific competition to offset their lower foraging ability. This result is different from ours, because the previous authors considered the optimal group size to be the size allowing the highest food intake rate (Alonso & Alonso, 1990), whereas we defined it according to the lowest vigilance effort. Avilés (2003) deemed that the time budget of adult Common Cranes did not vary with flock size, but adults devoted more time to vigilance than juveniles did. The differences from our conclusions are due to the previously mentioned different methods for classifying the flocks.

The vigilance effort of groups reflected that of each individual, the vigilance percentage of groups significantly declined as flock size increased (Fig. 3), which meant individuals in flocks devoted less and less time to vigilance. However the multiple comparison tests showed that the decrease of vigilance percentage of groups became not significant when flock size exceeded 30 individuals (there was no significant difference in vigilance effort of groups between "20 – 29" and "30 – 49", and between "30 – 49" and "> 50", Tab. 4). The maximal group size allowing the lowest vigilance effort for groups is still unknown, because the variation of vigilance percentage did not show significant increase. These results highlighted that flocks of 20 – 30 individuals may represent the optimal group size as a whole for wintering Common Cranes. Flocks above 30 individuals represented a threshold of intraspecific competition and further increases of group size would not decrease the vigilance effort any further due to the significant increase of vigilance duration between adult individuals. This further hints at the larger maximal group size allowing the lowest vigilance for juveniles compared with that for adults.

Compared with some species of Falconiformes birds and sparrow birds, for example the Bald Eagle *Haliaeetus leucocepha* and White-Crowned Sparrow *Zonotrichia leucophry*, the threshold size initiating the costs of flocking of Common Cranes is larger: the vigilance of Bald Eagles declined as group size increased from one to four individuals, and increased as group size ranged from eight to 14 individuals (Knight & Knight, 1986); while the group size of White-Crowned Sparrows exceeded 10 – 15 individuals; the vigilance would not decline further with an increase in proportion of active interactions (Slotow, 1996). It is presumed that the difference in interferential intensity or individual size and surrounding conditions leads to the difference in vigilance efforts of conspecific individuals, as Cranes don't have talons like the Falconiformes birds to use as attacking implements for food robbery among conspecific individuals. On the other hand, larger individual size make Cranes more adaptive to the surrounding conditions than sparrow birds. This suggests that among species there is obvious distinction in the effects of group size on the vigilance.

In conclusion, the vigilance efforts of Common Cranes decreased as group size increased, but the costs of flocking outweighed the benefit of lower vigilance efforts when the flock size exceeded a certain number. Flocks composed of 20 – 30 individuals represented the range of optimal group size of wintering Common Cranes

when considering only the vigilance behavior. However, the benefits of aggregation were decided by many factors, such as the intake rate, the benefits of family territorial behavior (Alonso et al, 2004) and the ability of searching. Further studies synthesizing various factors should be conducted.

**References:**


Alonso JA, Alonso JC. 1993. Age-related differences in time budgets and parental care in wintering Common Cranes[J]. *The Auk*, **110**(1): 78 – 88.

Alonso JA, Alonso JC, Bautista LM. 1994. Carrying capacity of staging areas and facultative migration extension in Common Cranes[J]. *Journal of Applied Ecology*, **31**(2): 212 – 222.

Alonso JC, Alonso JA. 1990. Costs and benefits of flocking in wintering Common Cranes[A]. In: Heilongjiang Forest Bureau. Proceedings 1987 International Crane Workshop[C]. Beijing: Chinese Forestry Publishing House, 158 – 163. (in Chinese).

Alonso JC, Bautista LM, Alonso JA. 2004. Family-based territoriality vs flocking in wintering Common Cranes *Grus grus*[J]. *Journal of Avian Biology*, **35**(5): 434 – 444.

Avilés JM. 2003. Time budget and habitat use of the Common Crane wintering in dehesas of southwestern Spain[J]. *Canadian Journal of Zoology*, **87**(7): 1233 – 1238.

Bautista LM, Alonso JA, Alonso JC. 1992. A 20 year study of wintering common crane fluctuations using time series analysis[J]. *Journal of Wildlife Manage*, **56**(3): 563 – 572.

Fleischer RC. 1983. Relationships between tidal oscillations and Ruddy Turnstone flocking, foraging, and vigilance behavior[J]. *The Condor*, **85**(1): 22 – 29.

Jiang ZG. 2004. Principles of Animal Behavior and Techniques of Species Conservation[M]. Beijing: Science Press. (in Chinese).

Knight SK, Knight RL. 1986. Vigilance patterns of Bald Eagles feeding in groups[J]. *The Auk*, **103**(2): 263 – 272.

Martella MB, Renison D, Navarro JL. 1995. Vigilance in the Greater Rhea: Effects of vegetation height and group size[J]. *Journal of Field Ornithology*, **66**(2): 215 – 220.

Petit DR, Bilestein KL. 1987. Effect of group size and location within the group on the foraging behavior of White Ibises[J]. *The Condor*, **89**(3): 602 – 609.

Pulliam HR. 1973. On the advantage of flocking[J]. *Journal of Theoretic Biology*, **38**: 419 – 422.

Quan RC, Wen XJ, Yang XJ. 2002. Effects of human activities on migratory waterbirds at Lashihai Lake, China[J]. *Biological Conservation*, **108**(3): 273 – 279.

Shang YC. 1998. Behavior Ecology[M]. Beijing: Beijing University Press. (in Chinese).

Slotow R. 1996. Aggression in White-Crowned Sparrows: Effects of distance from cover and group size[J]. *The Condor*, **98**(2): 245 – 252.

South JM, Jones SP. 2000. Patterns of flock size, diet, and vigilance of naturalized Monk Parakeets in Hyde Park, Chicago[J]. *The Condor*, **102**(4): 848 – 854.

Sun RY. 2001. The Principles of Animal Ecology (3rd)[M]. Beijing: Beijing Normal University Press. (in Chinese).


## 本刊编委陈宏伟教授简介

陈宏伟教授

陈宏伟,男,1960 年 9 月生。1983 年 7 月沈阳师范大学生物系毕业;2001 年 3 月获日本北海道大学地球环境科学博士学位。2001 年 7 月—2003 年 6 月作为日本学术振兴会外国人特别研究员,在东京都立大学进化遗传学研究室从事果蝇进化生物学研究。2003 年 7 月始,任华南农业大学资源环境学院教授。

主要研究领域为果蝇的系统分类学、动物地理学和进化生物学。发表果蝇研究论文 30 余篇,其中 SCI 论文 20 余篇。